

the aid of telegraphic reports received from western Europe, islands of the North Atlantic Ocean, and North America, and by a classification of types prepared by the aid of Weather Bureau and international reports. These preliminary studies appear to indicate recurring periods during which similar weather conditions and changes obtain generally over the middle latitudes of the Northern Hemisphere. A determination of these periods, with the data available, may not be possible.

The increased accuracy of the forecasts and the lengthening of the period for which they are made, which will surely follow a vigorous prosecution of this line of work, will, however, justify the great expenditure of time, labor, and skill which the preparation of reference charts and their classification will demand.

HAWAIIAN CLIMATOLOGICAL DATA.

By CURTIS J. LYONS, Territorial Meteorologist.

Meteorological observations at Honolulu, December, 1901.

The station is at 21° 18' N., 157° 50' W.
Hawaiian standard time is 10^h 30^m slow of Greenwich time. Honolulu local mean time is 10^h 31^m slow of Greenwich.

Pressure is corrected for temperature and reduced to sea level, and the gravity correction, -0.06, has been applied.

The average direction and force of the wind and the average cloudiness for the whole day are given unless they have varied more than usual, in which case the extremes are given. The scale of wind force is 0 to 12, or Beaufort scale. Two directions of wind, or values of wind force, or amounts of cloudiness, connected by a dash, indicate change from one to the other.

The rainfall for twenty-four hours is measured at 9 a. m. local, or 7.31 p. m. Greenwich time, on the respective dates.

The rain gage, 8 inches in diameter, is 1 foot above ground. Thermometer, 9 feet above ground. Ground is 43 feet, and the barometer 50 feet above sea level.

Date.	Pressure at sea level.		Temperature.		During twenty-four hours preceding 1 p. m. Greenwich time, or 2:30 a. m. Honolulu time.								Total rainfall at 9 a. m., local time.	
	Dry bulb.	Wet bulb.			Temperature.		Moisture.		Wind.		Average cloudiness.	Sea-level pressures.		
			Maximum.	Minimum.	Dew-point.	Relative humidity.	Prevailing direction.	Force.	Maximum.	Minimum.				
1.....	30.01	64.4	63.3	79	63	64.0	80	+	sw.	1-0	3-0	30.03	29.94	0.00
2.....	29.95	70.0	63.7	82	68	66.5	80	+	n.	1-0	1-9	30.05	29.91	0.00
3.....	29.98	74.4	67.1	81	68	68.5	82	+	sw.	1-0	5-0	30.04	29.93	0.00
4.....	29.99	74.4	67.5	80	66	68.7	82	+	ne	2-0	4-0	30.05	29.95	0.00
5.....	30.01	74.4	67.1	79	72	64.8	80	+	ne.	1-0	6-0	30.06	29.97	0.00
6.....	29.96	73	65.5	80	73	68.0	84	+	ne.	1-0	3-0	30.04	29.95	0.00
7.....	29.98	69	66	79	72	63.3	86	+	ne.	1-0	3-0	29.99	29.88	0.00
8.....	29.92	69	66	80	66	65.5	75	+	c-se.	1-0	1-3	29.90	29.80	0.09
9.....	29.81	64	63.3	74	66	65.7	88	+	w.	1-0	10-8	29.92	29.80	0.21
10.....	29.77	65	64	79	68	65.5	84	+	sw-n.	0	1-5	29.85	29.75	0.00
11.....	29.80	70	62	78	64	65.0	84	+	sw-w.	0-1	2-2	29.82	29.73	0.00
12.....	29.91	69	60	78	64	65.5	74	+	nw-n.	1-5	1-1	29.93	29.83	0.00
13.....	29.83	60	53	75	67	65.0	61	+	n	3-0	1-0	29.97	29.87	0.00
14.....	29.77	74	68	77	59	61.0	74	+	n-sw.	1-3	0-10	29.90	29.78	0.00
15.....	29.85	74	69	80	73	66.7	74	+	ws-w.	3-4	5	29.87	29.78	0.00
16.....	29.86	75	69	80	72	67.5	75	+	ws-w.	2-2	5	29.93	29.84	0.00
17.....	29.81	75	69	80	74	65.7	68	+	sw.	3	6	29.91	29.80	0.01
18.....	29.80	73	71	79	73	66.5	72	+	sw.	3-4	7-10	29.86	29.76	1.04
19.....	29.94	72	69.5	77	71	70.5	92	+	w-var.	0	10-8	29.94	29.80	0.22
20.....	30.05	67	65	79	68	68.0	84	+	se.	1	0	30.07	29.92	0.00
21.....	30.00	65	64	80	64	67.7	83	+	se.	1-0	0-5	30.09	29.98	0.00
22.....	29.86	69	66	79	64	66.7	85	+	sw.	1-0	1-7	30.03	29.86	0.04
23.....	29.80	65	64.7	70	67	64.5	91	+	w-n.	3-0	8-10	29.88	29.74	1.73
24.....	29.81	71	62	78	64	65.3	80	+	ne.	0-2	5-10	29.86	29.73	0.46
25.....	30.01	69	66.5	76	68	67.7	93	+	ne-e.	3-0	10	30.06	29.78	5.76
26.....	30.00	68	67.3	78	64	65.5	81	+	nne.	1-0	10-8	30.11	29.96	0.01
27.....	29.97	69	68.3	79	67	67.0	85	+	ne	0-3	8-4	30.06	29.94	0.10
28.....	29.91	69	68.3	77	67	68.5	87	+	sw.	1	8-4	29.98	29.89	0.20
29.....	29.97	68	61	73	67	64.0	84	+	nw-n.	1-6	10-2	29.90	29.80	0.10
30.....	30.06	67	59	72	65	56.5	65	+	nne.	5-7	3	30.06	29.95	0.00
31.....	30.11	66	59	71	65	52.3	56	+	n.	3-2	3	30.13	30.04	0.01
Sums.....														9.98
Means.....	29.926	69.4	65.5	77.4	67.1	64.1	76.2			1.7	5.0	29.980	29.862	
Departure.....	-0.047					+1.1	+1.2				+0.6			+6.06

*This pressure is as recorded at 1 p. m., Greenwich time. †These temperatures are observed at 8 a. m., local, or 4:31 p. m., Greenwich time. ‡These values are the means of (6+9+2+9) ÷ 4. §Beaufort scale.

Mean temperature for December, 1901, 72.1°; normal is 71.5°. Mean pressure for December, 1901, 29.923; normal is 29.970.

GENERAL SUMMARY FOR NOVEMBER, 1901.

Temperature mean for the month, 73.9°; normal, 73.8°; average daily maximum, 78.9°; average daily minimum, 69.0°;

average daily range, 9.9°; greatest daily range, 16°; least daily range, 3°; highest temperature, 82°; lowest, 63°.

Barometer average, 29.983; normal, 29.957 (corrected for gravity by -.06); highest, 30.18, on the 15th; lowest, 29.85, on the 27th; greatest 24-hour change, i. e., from any hour on one day to the same hour on the next, .09. Lows passed this point on the 7th and 27th; highs, on the 15th and 23d.

Relative humidity, 76.5 per cent; normal, 76.0; mean dew-point, 66.2; normal, 65.7; mean absolute moisture, 7.08 grains to the cubic foot; normal, 6.93.

Rainfall, 3.34 inches; normal, 5.52; rain record days, 18; normal, 17; greatest rainfall in one day, 0.80, on the 7th; total at Luakaha (Nuuanu near Pali) 14.76; at Kapiolani Park, 1.63. Total rainfall since January 1, 32.30; normal, 32.76.

Rainfall data.

Stations.	Elevation.	Nov., 1901.	Stations.	Elevation.	Nov., 1901.
HAWAII.			MAUI—Continued.		
Hilo, e. and ne.	Feet.	Inches.	Haleakala Ranch, n.....	2,000	10.56
Waialea	50	36.06	Wailuku, ne.....	200	3.56
Hilo (town)	100	38.89	LANAI.		
Kaunama	1,250	44.69	Keomuku, e.....		
Pepeekeo	100	25.56	OAHU.		
Hakalau	200	29.16	Punahou (W. B., sw.)	47	3.34
Honohina	300	35.85	Kulaokahua, sw.....	50	2.90
Laupahoehoe	500	28.30	Makiki Reservoir	120	3.88
Ookala	400	21.47	Kewalo (King street), sw.	15	2.99
HAMAKUA, ne			U. S. Naval Station, sw	6	1.95
Kukui	250	13.35	Kapiolani Park, sw.....	10	1.63
Paauilo	750	17.67	Manoa (Woodlawn Dairy), c.	285	7.07
Paauhau (Mill)	300	10.39	School street (Bishop), sw.	50	4.42
Paauhau (Greig)	1,150	17.67	Pacific Heights, sw.....	700	7.15
Honokaa (Muir)	425	10.15	Insane Asylum, sw.....	30	3.51
Honokaa (Rickard)	1,900	10.15	Kalihi-uka		
Kukuihaele	700	7.74	Kamehameha School.....	75	3.06
KOHALA, n.			Nuuanu (W. W. Hall), sw.	50	4.21
Awini Ranch	1,100		Nuuanu (Wylie street), sw.	250	7.24
Niuli	200	8.41	Nuuanu (Elec. Station), sw.	405	6.33
Kohala (Mission)	531	6.90	Nuuanu (Luakaha) c.....	850	14.76
Kohala (Sugar Co.)	285		Waianalo, ne.....	25	
Hawi	3-0		Maunawili, ne.....	300	6.18
Hawi Mill	600		Kaneohe, ne.....	100	
Waimea, c	2,720	2.95	Ahihi, ne.....	350	
KONA, w.			Kahuku, n.....	25	2.80
Kailua	950	6.73	Wailua, n.....	20	1.39
Holualoa	1,340	9.40	Wailua, c.....	900	1.86
Kealahou	1,580	6.99	Ewa Plantation, s.....	60	0.73
Napooopo	25	.59	Waipahu, s.....	200	1.71
KAU, se.			Moanalua, sw.....	15	2.73
Kahuku Ranch	1,680		KAUAI.		
Honouliuli	15	10.43	Lihue (Grove Farm), e.....	200	4.95
Nalehu	650	11.29	Lihue (Molokaa), e.....	300	4.44
Hilea	310	10.10	Lihue (Kukua), e.....	1,000	8.66
Pahala	850	6.85	Kealia, e.....	15	2.88
Moaula	1,700	12.58	Kilauea, ne.....	325	6.01
PUNA, e.			Hanalei, n.....	10	14.15
Volcano House	4,000	17.72	Wailua, sw.....	32	1.09
Olaa (Sugar Company)	221	31.47	Elele, s.....	200	3.42
Olaa (Mountain View)	1,690	45.86	Wailua, Mountain, s.....	2,100	21.85
Kapoho	110	14.80	McBryde (Residence).....	850	9.78
Kalapana, se.....	8		Lawai	450	0.03
MAUI.			Delayed October reports.		
Lahaina			Haleakala Ranch.....		0.65
Waloapa Ranch	700	5.49	Ki, ahulu.....		4.86
Kaupo (Mokulau), s.....	285	18.41	Waloapa Ranch.....		1.99
Kipahulu, s.....	300	18.01	Ewa Plantation.....		3.85
Kahikinui	1,550		Paauilo.....		5.10
Hamao Plantation, se.....	60	11.85	Laupahoehoe.....		10.01
Nahiku (Anderson), ne.....	60	13.59	Napooopo.....		0.57
Nahiku, (Nishwitz), ne.....	850	20.78	Nuuanu (Wylie Street).....		5.40
Haiku, n.....	700	7.94	Kapoho.....		5.09
Kula (Erehwon), n.....	4,500	2.89	Hakalau.....		8.70
Kula (Walaokaa), n.....	2,700	3.17	Honohina.....		18.79
Puomalei, n.....	1,400				
Pala, n.....	180	2.98			

The artesian well water has risen during the month from 33.12 to 33.56 feet above mean sea-level. On December 1, 1900 it stood at 33.62. The average daily mean sea level for November was 10.21 feet on the scale, 10.00 representing an assumed annual mean, and 9.82 the actual annual mean for nine years previous to 1901.

Trade wind days, 23 (5 of north-northeast), normal, 17; average force (during daylight) Beaufort scale, 2.6. Cloudiness, tenths of sky, 5.5; normal, 4.6.

Approximate percentages of district rainfall as compared with normal: Hilo, 300 per cent; Hamakua, 180; Kohala, 180; Waimea, 150; Kona, 125; Kau, 175; Puna, 170; Maui, east

coast, 200; Central, 120; Oahu, coast, 60 per cent; interior, 135; Kauai, 70 per cent.

The following heavy 48-hour rainfalls are noted: Olaa, Mountain View, 1,690 feet elevation, 30 inches on the 8th and 9th; Kaumana, 28.07 in 48 hours; Hilo (town), 26.08; same time, Waiakea, 24.62; same date, Paauilo, 12.46; two days, Ookala, 14.16.

Mean temperatures: Pepeekeo, Hilo district, 100 feet elevation, average maximum, 77.0°; average minimum, 68.6°; Waimea, Hawaii, 2,730 elevation, 73.9° and 63.0°; Kohala, 521 feet elevation, 76.8° and 68.3°; Olaa, Mountain View, 70.0 and 60.0; Waiakoa, Kula, 2,700 elevation, 75.5° and 59.0°; W. R. Castle's, Kulaokahua, 60 feet elevation, highest, 85°; lowest, 65.0°; mean, 73.6°; Ewa Mill, 50 feet elevation, average maximum 82.6°; average minimum, 67.1°; dew-point and relative humidity at same station, 67.6° and 79.0 per cent.

The main event of the month was the torrential downpour on Hawaii, mostly on the 8th and 9th, accompanied by north-northeast to east-northeast gales throughout the group. The rain was only moderate on Oahu and Kauai. There was an unusual absence of southerly weather for the month. Snow fell on Mauna Loa and Mauna Kea from the 5th to the 10th.

Earthquake at Hilo, 15th at 10 p. m., also a light one on the 21st. Heavy surf 8th to 14th.

NOTE.—A marked depression passed here on the 10th, the lowest barometer reading being about 29.93 inches. The wind shifted from west to southwest, then to northwest and ended with a norther on the 11th and 12th, which was a "Kona" at other points in the group. Another low passed on the 17th, and a third on the 23d. Quite likely these two latter were in reality one and the same, since the wind, during the passage of this first depression backed from north to southwest and then to northeast, giving Honolulu 5.76 inches of rain on the 24th.

GENERAL SUMMARY FOR DECEMBER, 1901.

Temperature mean for the month, 72.1°; normal, 71.5°; average daily maximum, 77.4°; average daily minimum, 67.1°; mean daily range, 10.3°; greatest daily range, 19°; least daily range, 3°; highest temperature, 82°; lowest, 59°.

Barometer average, 29.923; normal, 29.970 (corrected for gravity by —.06.); highest, 30.17, on the 31st; lowest, 29.73, on the 10th; greatest 24-hour change, i. e., from any given hour on one day to the same hour on the next day, 0.23; lows passed this point on the 10th and 22d; highs, on the 4th, 20th, and 31st. In the October report the following remark was made: "It will be interesting to note whether seven successive months of low barometer will be followed by unusually heavy rains." The report below will show whether this was well founded.

Relative humidity, 76.2; normal, 75; mean dew-point, 64.1°; normal, 63°; mean absolute moisture, 6.63 grains to the cubic foot; normal, 6.32. The dew-point was unusually low during the last three days of the month.

Rainfall, 9.98 inches; normal, 3.92; rain record days, 14; normal, 16; greatest rainfall in one day, 5.76 inches, on the 24th; total at Luakaha, 25.51; at Kapiolani Park, 9.33. Total rainfall since January 1, 38.96; normal, 37.00.

The artesian well level rose during the month from 33.56 to 34.05 feet above mean sea level. January 1, 1901 it stood at 34.00. It would seem that the lowering of the wells has come to a standstill, owing to the failure of the high level wells, and probably greater economy on the part of those at a low level.

The average daily mean sea level for December was 10.26 on the scale, 10.00 representing an assumed annual mean, and 9.82 the actual annual mean for nine years previous to 1901.

The following figures are from actual hourly measurements on sheets from self-recording tide gage made by Hugo Bilg-

nam, Stienle's pattern, and referred daily to standard bench mark. The work has been done by the Hawaiian Government Survey—now Territorial Survey—and the results are furnished by permission of the present surveyor: 1892, 9.869 feet; 1893, 9.844; 1894, 9.758; 1895, 9.688; 1896, 9.848; 1897, 9.969; 1898, 9.848; 1899, 9.690; 1900, 9.837; 1901, 10.173. Mean, 9.852.

Trade wind days, 7; normal, 14; 3 of north-northeast; average force of wind (during daylight), 1.7 Beaufort scale. Cloudiness, tenths of sky, 5.0; normal, 4.4

Approximate percentages of district rainfall. Hilo, 175 per cent; Hamakua, 140; Kohala, 130; Waimea, 100; Kona, 200 to 400; Kau, 175; Puna, 150; Maui, variable from 60 to 200; Oahu, 240; Kauai, 225.

There was a general and very heavy rainfall throughout the group on the 24th; 6 inches in twenty-four hours on Oahu, 10 inches in twenty-four hours in Hilo; at Ookala, north Hilo, 20 inches in twenty-four hours is reported on good authority, and at Laupahoehoe, Hilo, 30.50 inches is officially reported for the 24th and 10.80 for the 25th, which latter fell in the early part of the day, making 41.30 inches in the period of twenty-eight hours, a record that it is believed has only been surpassed by one in Queensland of 40 inches in twenty-four hours.

Rainfall data.

Stations	Elevation.	Dec., 1901.	Stations.	Elevation.	Dec., 1901.
HAWAII.			MAUI—Continued.		
Hilo, e. and ne.	<i>Feet.</i>	<i>Inches.</i>	Puuomalei, n.	<i>Feet.</i>	<i>Inches.</i>
Waialea	50	12.79	Pala, n.	1,400	5.80
Hilo (town)	100	.....	Haleakala Ranch, n.	180	3.06
Kaumana	1,250	14.70	Wailuku ne.	200	8.42
Pepeekeo	100	14.81	OAHU.		
Hakalau	200	14.98	Punahou (W. B.) sw.	47	9.98
Honohina	300	25.78	Kulaokahua, sw.	50	9.52
Laupahoehoe	500	49.07	Makiki Reservoir	130	9.60
Ookala	400	.....	Kewalo, (King street), sw.	15	.....
HAMAKUA, ne.			U. S. Naval Station, sw.	6	8.29
Kukalau	250	9.79	Kapiolani Park, sw.	10	9.33
Paauilo	750	11.82	Manoa (Woodlawn Dairy), c.	295	13.39
Paauhau (Mill)	300	6.70	School street, (Bishop), sw.	50	8.76
Paauhau (Greig)	1,150	.....	Pacific Heights, sw.	700	10.10
Honokaa (Mulr)	425	6.86	Insane Asylum, sw.	80	8.62
Honokaa (Rickard)	1,900	.....	Kalihi-uka, sw.	250	14.74
Kukuihale	700	6.43	Kamehameha School	75	8.71
KOHALA, n.			Nuananu (W. H. Hall), sw.	50	9.78
Awini Ranch	1,100	.....	Nuananu (Wyllie street), sw.	250	11.39
Niuli	200	2.80	Nuananu (Elec. Station), sw.	405	12.29
Kohala (Mission)	521	5.01	Nuananu (Luakaha) c.	850	25.51
Kohala (Sugar Co)	235	5.72	Waimanalo, ne.	25	15.39
Hawi Mill	600	.....	Maunawili, ne.	300	17.31
Waimea	2,730	4.33	Kaneohe, ne.	100	.....
KONA, W.			Abul' annu, ne.	350	17.04
Kailua	950	.....	Kahuku, n.	25	7.79
Kealahakua	1,580	7.07	Waialua, n.	20	7.07
Holualoa	1,350	4.75	Waialua, c.	900	10.32
Napoopoo	25	8.45	Ewa Plantation, s.	60	7.80
KAU, se.			Magnetic Station U. S. C. S.	45	9.03
Honuapo	15	4.87	Walpahu, s.	200	7.63
Naalehu	650	5.82	Moanalua, sw.	15	9.62
Hilea	310	6.80	KAUAI.		
Pahala	850	7.24	Lihue (Grove Farm), e.	200	7.02
Moaula	1,700	12.62	Lihue (Molokoa), e.	300	8.65
PUNA, e.			Lihue (Kukaua) e.	1,000	10.44
Volcano House	4,000	10.38	Keala, e.	15	6.45
Olaa (Mountain View)	1,700	14.93	Kilauea, ne.	323	13.73
Kapoho	110	9.43	Hanalei, n.	10	15.41
Kalapana se	8	.....	Waialua, sw.	82	6.73
MAUI.			Eleele, s.	200	.....
Waipae Ranch s.	700	5.17	Waialua, Mountain, s.	2,100	.....
Kaupo (Mokulau) s.	285	11.87	McBryde (Residence)	850	10.18
Kipahulu s.	300	12.17	Lawai	450	10.99
Hamoa Plantation s.	60	5.82	Delayed November reports.		
Nahiku, (Anderson), ne.	60	5.87	Kahuku, Pine Grove	1,680	8.02
Nahiku, (Nishwitz), ne.	800	16.55	Kohala Sugar Co	234	10.75
Haiiku n.	700	4.37			
Kula, (Erehwon) n.	4,500	.....		

Mean temperatures: Pepeekeo, Hilo district, 100 feet elevation, average maximum, 77.6°; average minimum, 67.8°; Waimea, Hawaii, 2,730 feet elevation, 73.7° and 61.6°; Kohala, 521 feet elevation, 76.8° and 67.7°; W. R. Castle, Kulaokahua, 60 feet elevation, highest, 80°; lowest, 59°; average for year, 74.42°. Ewa Plantation, 50 feet elevation, mean maximum, 81.2°; mean minimum, 64.8°; mean dew-point, 64.4°.

The two storm periods of the month were about the 8th and

24th, both preceded by heavy swell and followed by low dew-point. The north wind evidently precipitated the terrific downpour on north Hilo. There was lightning reported from Hawaii for the 8th, 9th, 13th, 24th, and 25th, and Maui on the 8th. Snow fell on Mauna Kea and Mauna Loa on the 8th and 24th; on Haleakala on the 8th or 9th. Earthquake reported at Hilo, 7:30 p. m. on the 2d.

AN AURORAL-LUNAR HALO DISPLAY.

H. H. TEN BROECK, Braidentown, Fla., dated December 29, 1901.

At midnight of the 28th I observed an auroral display with an axis extending about west-northwest to east-southeast. There was at the time an unusually brilliant halo around the moon, about 45° in diameter. The upper half was fringed on the edge by rays about 3° or 4° long, a few much longer, radiating, not from the moon (the center of the halo), but from a point below it about east-southeast on the horizon. Some of the rays extended northward as far as Cassiopeia while the Pleiades were a little south of the center of the long bands, which converged toward a point about west-northwest on the horizon, although not reaching it by 10° or 15°. The bands and the rays on the halo appeared and disappeared slowly like auroral bands and were of a pale white color. There was an 8 or 10 mile southeasterly wind blowing and half of the sky was covered with very light clouds of a cirro-cumulus order, with an almost imperceptible motion. Very few of the bands extended below the moon. The fringe of rays on the upper edge of the halo was well marked and closely resembled that often seen on an auroral arch; it, too, changed in brightness, slowly, as well as in length. It was a well-marked auroral display, with the moon's halo as a starting point. In half an hour the halo and bands had disappeared as well as most of the clouds.

I have never before seen or heard of an aurora from a lunar halo, nor one with its middle line running west-northwest and east-southeast.

MEXICAN CLIMATOLOGICAL DATA.

Through the kind cooperation of Señor Manuel E. Pastrana, Director of the Central Meteorologic-Magnetic Observatory, the monthly summaries of Mexican data are now communicated in manuscript, in advance of their publication in the Boletín Mensual. An abstract, translated into English measures, is here given, in continuation of the similar tables published in the MONTHLY WEATHER REVIEW since 1896. The barometric means are now reduced to standard gravity.

Mexican data for December, 1901.

Stations.	Altitude.	Mean barometer.	Temperature.			Relative humidity.	Precipitation.	Prevailing direction.	
			Max.	Min.	Mean.			Wind.	Cloud.
Chihuahua.....	Feet.	Inch.	° F.	° F.	° F.	%	Inch.		
Guadalajara.....	4,069	25.33	80.6	23.0	53.8	47	.....	ne.	.....
(Obs. del Est.)	5,186	24.90	83.7	40.1	58.1	51	.....	n.	.....
Guanajuato.....	6,640	23.66	79.2	30.7	57.0	49	.....	ws.w.	.....
Leon (Guanajuato)...	5,906	24.27	73.6	28.6	54.7	50	0.05	n.w.	.....
Mazatlan.....	25	29.89	79.5	55.9	70.0	71	.....	n.w.	w.
Merida.....	50	29.94	83.2	48.9	71.4	75	0.16	ne.	.....
Mexico (Obs. Cent.)...	7,472	23.01	71.2	30.9	52.5	51	.....	T.	.....
Monterrey (Sem.)...	1,636	28.20	97.7	31.1	57.9	54	.....	ne.	.....
Morelia (Seminario)...	6,401	23.91	73.0	30.2	54.9	60	.....	sw.	.....
Puebla (Col. Cat.)...	7,125	23.30	71.6	35.6	55.6	57	0.03	e.	.....
Puebla (Col. d. Est.)...	7,118	23.32	72.3	26.6	53.6	60	0.06	ene.	.....
Saltillo (Col. S. Juan)	5,399	24.76	72.7	29.9	51.4	55	.....	sw.	.....
Toluca.....	8,812	21.92	68.7	20.1	47.1	55	0.05	w.	.....
Tuxtla (Gutierrez, Chiapas)...	1,864	28.10	94.6	47.8	71.6	72	.....	n.w.	.....
Zapotlan.....	5,078	25.05	77.0	41.7	60.4	51	T.	n.	.....

* Reduced to standard temperature and gravity.

THE PHYSICAL BASIS OF LONG-RANGE WEATHER FORECASTS.¹

By PROF. CLEVELAND ABBE.

The expression "long range" must not be misunderstood. It refers only to the length of time intervening between the date of making a weather prediction and the date when we expect it to be fulfilled. At the present time, by the help of the daily weather map, the official weather forecasters of this country, and indeed of every civilized nation on the globe, publish forecasts, in detail, of approaching weather changes, and especially storms, for one and two, or possibly occasionally three days in advance. These predictions all relate to comparatively minute details for regions that have been charted and studied daily for many years. They merely represent the direct teachings of experience; they are generalizations based upon observations but into which physical theories have as yet entered in only a superficial manner if at all. They are, therefore, quite elementary in character as compared with the predictions published by astronomers, based on the laws of gravitation and inertia, or the predictions sometimes offered by chemists, based on the laws that are being worked out by these investigators. Even the electrician, familiar with mathematical physics ventures on predictions based on far more complex theories than are as yet at the command of the meteorologists. But the latter are slowly building a grand structure, mathematical, graphical, and numerical, in which deductive reasoning will take the place of empirical rules. The whole will eventually form a complex intellectual machine, by means of which the general, and possibly the detailed phenomena of the atmosphere, will be followed up day by day. Then we shall be justified in calling our work rational science, as distinguished from empirical science. I use the word science in its fundamental meaning, as referring to that of which we have accurate knowledge, and not that which is purely speculative.

While I thus indulge hope in the prospective future high perfection of the science of the weather, I recognize the fact that we must not expect to realize these hopes in this generation. The progress of all science is necessarily slow. From Copernicus to Kepler, from Kepler to Newton, from Newton to La Place, and from La Place to the living giants in the theoretical astronomy of to-day, we proceed by steps of a century each. In chemistry, from Berzelius to the present day, we have scarcely one such step. In electrical science we are less than a century distant from Ohm and Green. In meteorology, considered as an application of physics, we begin with Espy's work of 1830, but considered as a branch of mathematical science we begin with Ferrel's work of 1856. The development of a correct "Theoria meteorologica" has made good progress during the past twenty years, but we are still at work on the introductory chapter. Some would hasten the work by unnatural stimulants in response to the feverish anxiety of the people and the daily newspapers, but we must be content to await the surer results of a slow but natural growth. Personally, I hope I may live to see the day when some of our universities will offer attractive courses in dynamic, experimental, and observational meteorology to advanced students of mathematics and physics, when those who are prepared to profit by such lectures may in their turn contribute to the advancement of our knowledge. It will not do for us to be so absorbed in so-called practical work as to neglect the research work that is still more practical. The practical work of to-day is but the application of the results of the past research. The research of to-day will be the basis

¹This paper is a summary of lectures delivered at Johns Hopkins University in February, 1901. It was prepared for the meeting of the American Association for the Advancement of Science, Denver, August, 1901, and is now first published.